Telecommunications Industries Analysis Project

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July 22, 1998

CC Docket Nos 98-11, 98-26, 98-32
98-78, 98-91

Ms. Magalie Roman Salas
Secretary of the Commission
1919 M Street, NW, Room 222
Washington, DC 20554

Dear Ms. Salas,

I am filing the attached research paper in my role as faculty member and academic researcher at the Warrington College of Business Administration, University of Florida. This is an informational document for the FCC's 706 Inquiry on Advanced Telecommunications Capability.

The enclosed paper is *The Electronic Apple Pie: Deploying Advanced Telecommunications Capabilities to All Americans* as well as an executive summary.

The Telecommunications Industries Analysis Project (TIAP) is a neutral forum that presents multiple viewpoints to assist policy makers in their decision making. This paper is a primer and does not endorse or propose a particular policy or technology. This paper is intended to provide general public information and does not constitute or foretell the official position of any of the parties who contributed to this paper. The opinions expressed in this paper do not necessarily reflect the views of any agency, company, or individual TIAP participants.

In accord with FCC guidelines, I am submitting two original's of the paper and executive summary.

Sincerely,

Carol Weinhaus

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Meeting House Offices
121 Mount Vernon Street, Boston, MA 02108

The Electronic Apple Pie: Deploying Advanced Telecommunications Capabilities to All Americans

Executive Summary

July 21, 1998

Presentation at the July 1998 NARUC Meeting
Seattle, WA

Telecommunications Industries Analysis Project

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The Electronic Apple Pie: Deploying Advanced Telecommunications Capabilities to All Americans, *Executive Summary*

Objective

This paper provides policy makers with a primer on technologies for traditional telephone networks (circuit-switched technology) and data networks (packet-switched technology), and explains how voice, data, and video networks are converging. To provide background for policy decisions, the paper explains and illustrates how customers use different types of networks (telephone, computer, wireless, cable TV, and satellite) to get their services.

Consequence of Network Convergence

A natural consequence of network convergence is that the traditional, technology-specific approach to regulatory policy will tend to become outdated in favor of a more integrated approach.

Section 706 of the *Telecommunications Act of 1996*

While a change of regulatory focus would tend to occur naturally over time, Section 706 of the *Telecommunications Act of 1996*[1] requires viewing various voice, data, and video networks as a whole to determine the most effective policies for encouraging deployment of advanced telecommunications capabilities.

What actions does Section 706 require?

Section 706 of the *Act of 1996* requires that the Federal Communications Commission (FCC) initiate and complete an inquiry of deployment of advanced telecommunications capability by February 8, 1999.[2] In this inquiry, the FCC must look at the fundamental relationships among regulation, deregulation, competition, and investment for these advanced capabilities. Then, the FCC must determine the following:

- Are advanced telecommunications capabilities being deployed to all Americans?
- Are advanced telecommunications capabilities being deployed in a reasonable and timely basis?

If the FCC determination is negative, it must take immediate action to:

- Consider if any regulations or policies are a deterrent to the rapid deployment of advanced services
- Remove any regulations that are found to be a deterrent
- Promote competition

The FCC is required to determine if the current pace of deployment of an advanced infrastructure meets both the timeliness and ubiquitous deployment required in the *Act of 1996*. Answering these questions requires an understanding of current networks and the capability of current networks to provide high-quality voice, data, graphics, and video services.

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[1] Telecommunications Act of 1996, Pub. L. No. 104-104, Stat.56, codified at 47 U.S. C. §§ 151 et seq., Section 706.

[2] *Ibid.*, Section 706(b). The *Act of 1996* requires the FCC to initiate an inquiry "within 30 months after the date of enactment of this Act" and to complete this inquiry 180 days later.

What policy questions need to be answered?
The focus of Section 706 is assuring the deployment of advanced capabilities and promoting competition. While most parties will agree with these goals, there are diametrically opposing views as to what policies will accomplish both goals.

Controversy exists over whether any action must be taken to encourage investment in infrastructure or whether Section 706 is a mandate for the FCC to take action and to develop policies to provide incentives for investment and competition.

List of Policy Questions
While this paper does not discuss policy issues, it raises some of the many questions that may be addressed in the FCC's inquiry. The paper provides a technical foundation for discussing the Section 706 issues:

- *How do you define the mandates of Section 706, and are current policies accomplishing these mandates?*
- *What incentives would provide a company with a viable business case for deploying advanced technologies to all Americans?*
- *Is there a role for subsidies?*
- *Is regulation a barrier to deployment of advanced capabilities?*
- *Does regulatory forbearance in Section 706 apply to other sections of the Act of 1996?*
- *What are some of the issues related to access to the local exchange network?*
- *If network components are not considered essential, should they be subject to regulation?*
- *What issues are related to the Internet network?*
- *What issues are related to other industries (i.e., cable TV, wireless, and satellite) that are subject to regulation?*

Network Convergence — Different Viewpoints
Not all customers reach the Internet in the same manner with the same technologies. Companies have different customer prices and connection points. The result is that there are different views on whether or not there is a technical issue associated with the ability of a customer to reach the Internet through any given service. Network congestion includes factors such as network design, network reliability, bandwidth limitations, and customer equipment and software — all of which affect a customer's ability to access the Internet.

Project Information

List of Participants in the Telecommunications Industries Analysis Project

July 1998

State Regulators	NARUC Representatives from: California Public Utilities Commission Florida Public Service Commission Illinois Commerce Commission Iowa Utilities Board
Companies and Governments	AT&T Bell Atlantic BellSouth Corning GTE Business Development and Integration Kalona Cooperative Telephone MCI Telecommunications Corp. NTT America SBC Communications Inc. Sprint U S WEST

Sponsors:

Corporation for Public Broadcasting

Assisting with *public* data:

Bellcore
Federal Communications Commission
National Exchange Carrier Association
National Telecommunications and Information Administration

Project Information, cont.

Background on the Telecommunications Industries Analysis Project

The Telecommunications Industries Analysis Project (TIAP), a seven-year-old research consortium, conducts and reports impartial research in the areas where network planning, business financials, and public policy (regulation and legislation) intersect. The participants actively work together to develop new options for telecommunications policies to meet the needs of consumers, governments, and companies in a changing, competitive environment. Participants include regulators, domestic and foreign telecommunications companies, materials and equipment manufacturers, and other communications-based organizations.

The purpose of the Project is to produce research and analysis that will assist policy makers in making informed decisions.

TIAP incorporates the following features:

- **Neutral setting**
  The Project provides a neutral setting, free of partiality, thereby ensuring objective and independent research.

- **Multiple viewpoints**
  Participants play an active role in the research and analysis, represent their own interests, and understand and assist in developing others' perspectives.

- **Analysis and results of alternatives**
  The Project provides research data, tools, and models for critical decision making.

- **Public distribution of research**
  Data used by this Project are publicly available. Research products become public domain information.

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Copyright and Project Address

Telecommunications Industries Analysis Project:

The Electronic Apple Pie: Deploying Advanced Telecommunications Capabilities to All Americans

Carol Weinhaus, Larry Stevens, Sandra Makeeff, *et al.*
July 21, 1998

Presentation at the July 1998 NARUC Meeting, Seattle, WA.

The views expressed in this paper do not necessarily reflect the viewpoints of individual participants.

The Telecommunications Industries Analysis Project is associated with the Public Utility Research Center at the University of Florida Warrington College of Business Administration.

In addition to the work of project participants, the project appreciates the reviews of this primer by Jim McConnaughey and Joe Gattuso of the National Telecommunications and Information Administration.

For more information on the Project, contact Carol Weinhaus at the Project's address:

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List of Acronyms

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ADSL	Asymmetric Digital Subscriber Line
ALI	Automatic Location Information
ATM	Asynchronous Transport Mode
CLEC	Competitive Local Exchange Carrier
CMTS	Cable Modem Termination System
DBS	Direct Broadcast Satellite
DS-0	Digital Service 0
DS-1	Digital Service 1
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Multiplexer
FCC	Federal Communications Commission
FSN	Full Service Network
FTTC	Fiber-to-the-Curb
GHz	Gigahertz
HDSL	High Bit Rate Digital Subscriber Line
HFC	Hybrid-Fiber Coax
Hz	Hertz
IDSL	"ISDN" Digital Subscriber Line
ILEC	Incumbent Local Exchange Carrier
InterLATA	Inter Local Access and Transport Area
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
IWF	Inter-Working Function
kbps	Kilobits per Second
kHz	Kilohertz
LAN	Local Area Network
LEC	Local Exchange Carrier
Mbps	Megabits per Second
MHz	Megahertz
Modem	Modulator/Demodulator
MUX	Multiplexer
NAP	Network Access Point
NID	Network Interface Device
NIU	Network Interface Unit
NSP	Network Service Provider
OC-1	Optical Carrier-1, or Optical Carrier Base Rate of 51.84 mbps
OC-3	Optical Carrier-3
OC-12	Optical Carrier-12
OC-48	Optical Carrier-48
OC-192	Optical Carrier-192
ONU	Optical Network Unit
PCS	Personal Communications Service
POP	Point of Presence
PSTN	Public Switched Telephone Network

List of Acronyms, cont.

RADSL	Rate Adaptive Digital Subscriber Line
SDSL	Symmetric or Single Line Digital Subscriber Line
SMSC	Short Messaging Service Center
SONET	Synchronous Optical Network Elements for Transport
VDSL	Very High Rate Digital Subscriber Line
xDSL	Family of Digital Subscriber Line Technologies
TV	Television
UNE	Unbundled Network Element
U.S.	United States

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- **Public distribution of research**
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I. Introduction

Introduction

The objective of this paper is to provide policy makers with a primer on technologies for traditional telephone networks (circuit-switched technology) and data networks (packet-switched technology), and to explain how voice, data, and video networks are converging.

The paper identifies policy questions that need to be answered in order to encourage deployment of advanced telecommunications capabilities, as required by Section 706 of the *Telecommunications Act of 1996* (hereinafter referred to as the *Act of 1996*).[1] It then provides a simple overview of the technical background associated with answering these policy questions.

While this paper will not cover policy issues, it serves as a baseline for policy discussions centered on networks and services. It provides a technical foundation that includes current areas of network convergence. For example, this paper illustrates how customers reach the Internet through different types of networks (telephone, computer, wireless, cable TV, and satellite). This paper also explains the capabilities and limitations of circuit-switched and packet-switched networks.

A natural consequence of network convergence is that the traditional, technology-specific approach to regulatory policy will tend to become outdated in favor of a more integrated approach. While this change of regulatory focus would tend to occur naturally over time, the Section 706 mandate creates a more immediate need to view the various voice, data, and video networks as a whole to determine the most effective policies for encouraging deployment of advanced telecommunications capabilities.

The sections in this paper cover the following items:

- **Section II, What are the policy questions?:** Describes what the regulatory world is being asked to consider by the *Act of 1996*. This section keys up the policy questions that will need to be answered.
- **Section III, Network/Service Basics:** Lays out the basics of circuit-switched networks and packet-switched networks. This includes how customers access the Internet through a variety of networks and services.
- **Section IV, Network Convergence — Current Examples:** Illustrates current examples where various networks are combining circuit-switched and packet-switched technologies. This includes the convergence of voice, data, and video in various networks.
- **Section V, Network Convergence — Different Viewpoints:** Provides different views on the ability to reach the Internet's packet-switched network through various routes. This section includes some views of network congestion, bandwidth limitations, network reliability, and other issues associated with technology.

I. Introduction, cont.

- **Section VI, Appendix A: Legislative and Regulatory Background:** Contains a brief description of the legislative and regulatory background, including the text Section 706 (advanced telecommunications capability) of the *Act of 1996*.
- **Section VII, Appendix B: Additional Technical Background:** Provides additional technical background on data packets, voice over the Internet (including latency), and loop technologies.
- **Section VIII, Notes**

II. What are the Policy Questions?

What actions does Section 706 require?

Section 706 of the *Act of 1996* requires that the Federal Communications Commission (FCC) initiate and complete an inquiry of deployment of advanced telecommunications capability by February 8, 1999.[2] In this inquiry, the FCC must look at the fundamental relationships among regulation, deregulation, competition, and investment for these advanced capabilities. Then, the FCC must determine the following:

- Are advanced telecommunications capabilities being deployed to all Americans?
- Are advanced telecommunications capabilities being deployed in a reasonable and timely basis?

If the FCC determination is negative, it must take immediate action to:

- Consider if any regulations or policies are a deterrent to the rapid deployment of advanced services.
- Remove any regulations that are found to be a deterrent.
- Promote competition.

The FCC is required to determine if the current pace of deployment of an advanced infrastructure meets both the timeliness and ubiquitous deployment required in the *Act of 1996*. Answering these questions requires an understanding of current networks and the capability of current networks to provide high-quality voice, data, graphics, and video services.

What policy questions need to be answered?

The focus of Section 706 is assuring the deployment of advanced capabilities and promoting competition. While most parties will agree with these goals, there are diametrically opposing views as to what policies will accomplish both goals.

Controversy exists over whether any action must be taken to encourage investment in infrastructure or whether Section 706 is a mandate for the FCC to take action and to develop policies to provide incentives for investment and competition.

The following are some of the many questions that may be addressed in the FCC's inquiry:

How do you define the mandates of Section 706 and are current policies accomplishing these mandates?

- What speed is high speed?
- What is the current status on deploying advanced capabilities?
- What is a reasonable timetable for deployment of advanced capabilities "to all Americans?"

II. What are the Policy Questions, cont.

What incentives would provide a company with a viable business case for deploying advanced technologies to all Americans?

- Deployment incentives
- Meeting customer needs
- Quality of service

Is there a role for subsidies?

- Low-income households
- High-cost areas
- Special needs customers
- Specific services
- Schools, libraries, and rural health care providers

Is regulation a barrier to deployment of advanced capabilities?

- If yes, should advanced services be deregulated? If deregulated, should companies be required to offer services through a separate subsidiary?
- If not deregulated, what type of regulation would promote infrastructure investment and competition?
- How do you define the barrier? What is its source? What are the risks? What are the rewards?
- If a portion of the network is regulated, who has jurisdiction?
- Would jurisdictional separations be a barrier to infrastructure development and competition?

Does regulatory forbearance in Section 706 apply to other sections of the Act of 1996?

- Section 251 (interconnection)
- Section 253 (conflicting authority between federal and state regulatory treatment)
- Section 271 (Bell Operating Company entry into interLATA services)
- Section 272 (separate affiliate safeguards for the ILECs)
- Section 10 of the Communications Act of 1934 (relation to regulatory forbearance in Section 706)

II. What are the Policy Questions, cont.

What are some of the issues related to access to the local exchange network?

- Co-location
- Resale
- Interconnection
- Unbundled Network Elements (UNEs)
- New technologies
- Operational Support Systems
- Provisioning
- Maintenance
- Billing

If network components are not considered essential, should they be subject to regulation?

- What is the definition of essential?
- How does this relate to interconnection?

What issues are related to the Internet network?

- Compensation
- Capacity
- Interconnection

What issues are related to other industries (i.e., cable TV, wireless, and satellite) that are subject to regulation?

- Policies for infrastructure deployment
- Ubiquitous deployment
- Interconnection
- Subsidies

III. Network/Service Basics

What technical information is needed to answer policy questions?

In order to answer the policy questions listed in **Section II** of this paper, it is necessary to understand the underlying technologies and to understand how different companies and industries connect with one another or are unable to connect. In order to determine whether advanced telecommunications capabilities are deployed to all Americans on a reasonable and timely basis, it is necessary to understand what is being deployed today. In order to decide whether it is possible to treat voice and data services differently, it is necessary to understand the difference between circuit-switched and packet-switched networks.

This section of the paper covers how customers of traditional industries connect to the traditional telephone network (circuit-switched) and to the Internet (packet-switched). Companies have a variety of technical options. Understanding the difference between a circuit-switched network and a packet-switched network provides background for answering policy questions on network regulation and on access to network components. Understanding the current status of different industry-related technologies provides background for examining reasonable deployment timetables. Since the *Act of 1996* makes no distinction as to which industries will provide advanced capabilities, this paper covers various industries that have been traditionally linked to specific technologies — telephone, Internet, wireless, cable TV, and satellite. The regulatory treatment of these industries also differs.

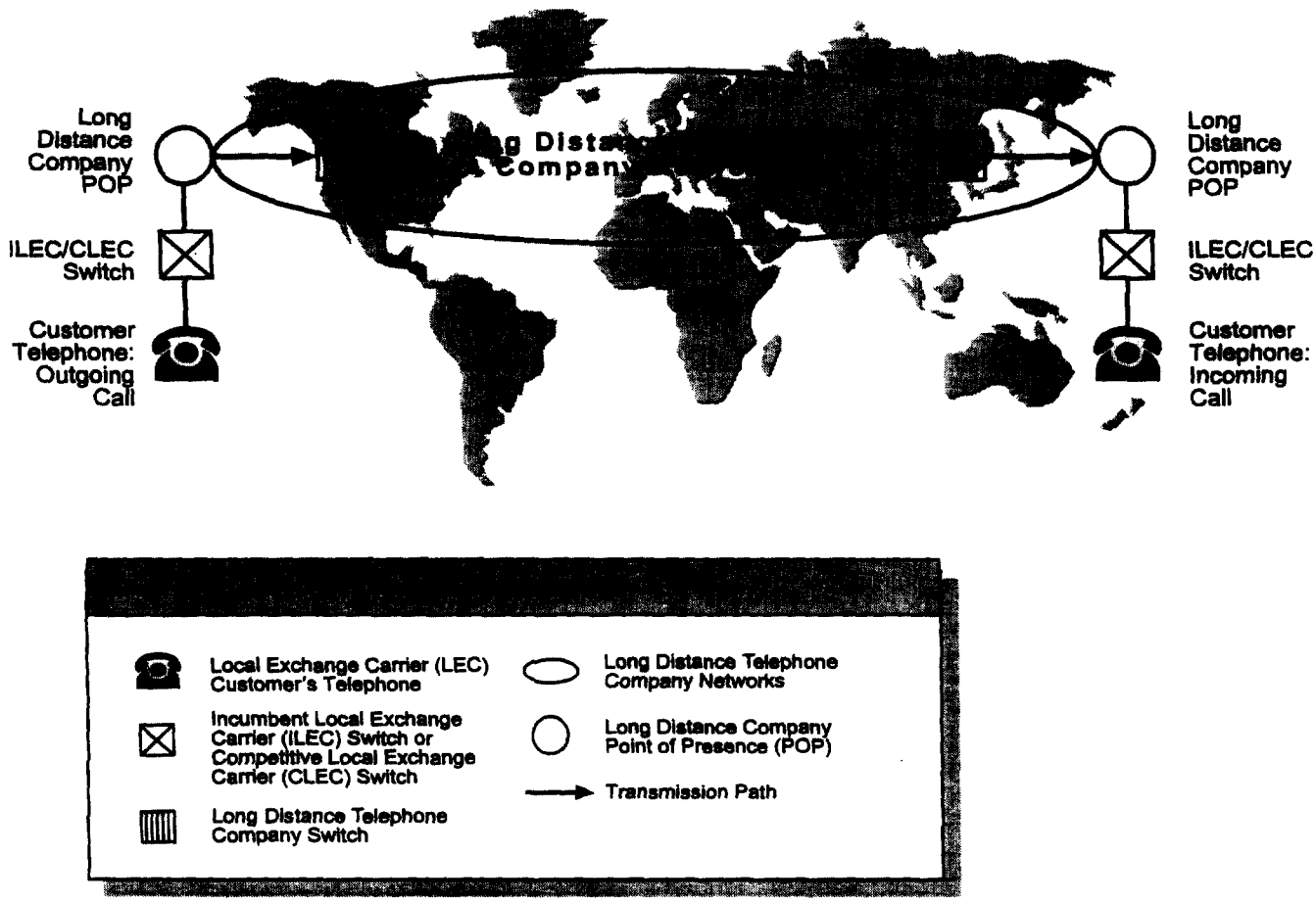
What is the traditional route over the Public Switched Telephone Network (PSTN)?

The traditional telephone network is owned by many different companies. Sometimes this interconnected group is loosely referred to as the "Public Switched Telephone Network" or simply by the acronym "PSTN." For purposes of discussion, this paper refers to this confederation of interconnected telephone networks as the PSTN.

In the PSTN, calls are completed using combinations of local, interoffice, and long distance telephone facilities (also known as interexchange carriers, or IXCs). **Figure 1** shows a simplified diagram of a typical long distance call using the PSTN. A call is first routed from the customer to an incumbent local exchange carrier (ILEC) or competitive local exchange carrier (CLEC) switch. The call is then routed to the appropriate long distance company's Point of Presence (POP). Regulations require all local exchange carriers (LECs) to provide interconnection to long distance companies (IXCs) through POPs. The selected long distance company then routes the call to another of its POPs located nearest to the called party. From this second POP, the call is routed to the party being called.

When a customer originates a call by dialing a telephone number, the intelligence (software) contained within the switches and other external databases provides the necessary information to route the call to the appropriate long distance company's POP. Customers may have a pre-subscribed long distance company or may select a particular long distance company at the time of the call.

Figure 1: Traditional Telephone Route through the Public Switched Telephone Network (PSTN) — Circuit-Switched



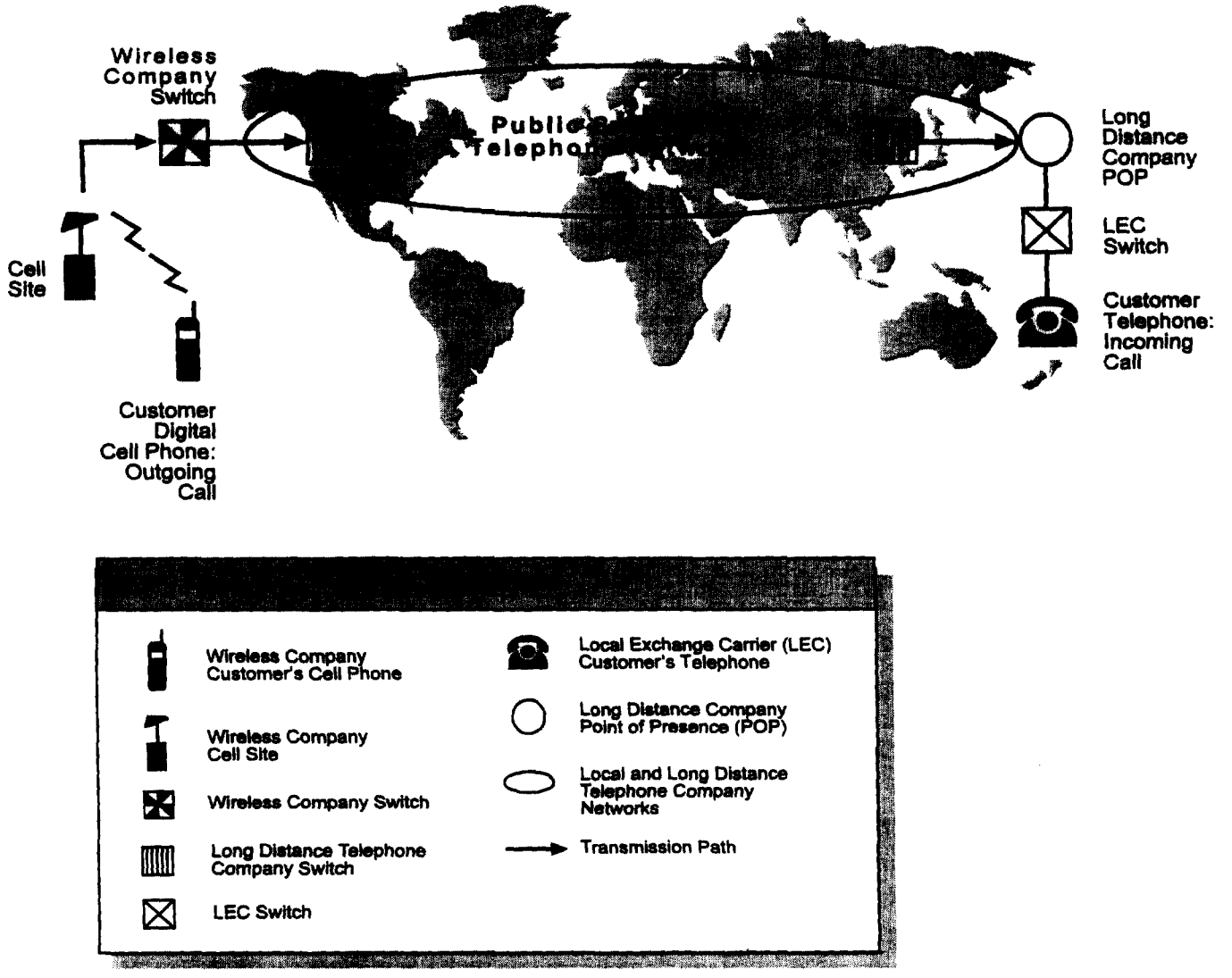
The PSTN traditionally has used circuit-switched technology. In the route shown in **Figure 1**, circuits are connected to provide a single voice-grade, simultaneous, two-way connection. Generally speaking, facilities used between the customer and the ILEC/CLEC switch are analog, voice-grade transmission paths. Voice communications are converted from an analog signal to a digital signal at the ILEC/CLEC switch and passed to the long distance carrier in digital format.[3] The long-distance telephone network in the United States is now almost entirely comprised of digital switches and fiber optic transmission links. In areas where local switches are not digital, conversions to analog formats are completed prior to reaching the analog facilities.

What is the wireless route through the PSTN?

Wireless communications through the PSTN involve the use of over-the-air signals (radio frequencies) in a portion of the communications path. **Figure 2** shows a typical wireless-to-PSTN connection. The customer uses a wireless handset to transmit and receive voice and data from an antenna located in a cell site (generally on a tower, a telephone pole, or a building) in the wireless company's cell (the calling area served by the antenna). Wireless cell sites are connected to the wireless company's switch. Intelligence (software) within the wireless switch or in other databases determines the route of the call. In **Figure 2**, the choice is limited to routing the call to the PSTN. However, other destinations, such as another wireless company or wireless customers attached to the same wireless company switch, are possible.

Since signal strengths are critical for the proper performance of a wireless communications system, the signal transmission power and distance between the user and cell site are important factors. In addition, the over-the-air transmissions can be either in analog or digital format, may use different transmission standards, and may use different segments of the frequency spectrum. Each wireless company determines which format and standards it will use to deliver services. In the evolution of wireless service, digital systems are the more advanced technology. The same is also true for wireline services.

Figure 2: Wireless Route through the Public Switched Telephone Network (PSTN) — Circuit-Switched



What is the Internet?

The Internet is a communications media that is a network of networks; it is plastic, decentralized, and constantly evolving. The Internet is an interconnected global computer network of tens of thousands of packet-switched networks using the Internet Protocol (IP). The following definitions describe the major aspects of Internet technology and identify some types of companies:

- *Packets:*
  The term "packet" is used to describe the type of network, since the digital data or information passing through the networks has been grouped or segmented into blocks or pieces called packets. The rules identifying the format of the packets is called the Internet Protocol (IP).

- *Internet Protocol (IP):*
  IPs are established standards used in the exchange of data between the users of the Internet. Protocols establish the rules for breaking files into blocks or packets and the rules for placing information within each packet on its source of origination and destination. Protocols also identify the timing of data transmission between users. In short, most information, such as voice, data, and video can be transported through the network if the data packets conform to the standards.

- *Internet Service Provider (ISP):*
  An ISP is a vendor that provides direct access to the Internet. Service providers appear in many different forms, from an independent business enterprise to services being provided by a local telephone service provider, a long distance telephone service provider, a cable television service provider, or a wireless service provider. Internet service providers connect customers to the Network Service Providers (NSPs) or backbone service providers. ISPs may also own and manage data networks.

- *Network Service Provider (NSP):*
  NSPs are the players that provide the Internet long-haul facilities or backbone facilities over a large region. These players typically own or lease long-haul, fiber-optic cables. Many of the NSPs link their facilities together to provide the global connectivity that is the Internet. The connection point between an ISP and an NSP may be at the ISP location. In other cases, ISP's may be required to build or lease facilities to reach the NSP. Network Access Points (NAPS) can also be a point of connection for NSPs and ISPs.

- *Network Access Point (NAP):*
  NAPs serve two functions. NAPs may be physical locations where the networks of NSPs physically connect with each other. NAPs may also provide facilities for ISPs to connect with NSPs. These connections are through contracts called "peering arrangements."[4] There are public and private NAPs. During the earlier stages of the Internet, the government sponsored the public NAPs, later followed by industry-run public peering points. There are also privately run NAPs.